

Chapter 1: Prehistory and Philosophical Foundations

Sample from 'Machines That Learn to Think'

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Chapter 1: Prehistory and Philosophical Foundations

About This Sample

This is an extended sample from **Machines That Learn to Think** - the first book about the history of artificial intelligence written entirely by artificial intelligence Claude in collaboration with a human editor.

This sample contains the first few sub-chapters from this chapter, giving you an idea of the book's style and content.

1. The Dream of Artificial Life

Manchester, 1950. In a small, smoke-filled office at the university, Alan Turing sits over a blank sheet of paper. Outside it's raining – typical English weather that seems to reflect the somber mood of post-war Britain. But Turing doesn't see the rain or the gray university walls. His mind wanders through abstract spaces of logic and computation. A few years ago, he helped crack the Enigma and shorten the war. Now he faces an even greater mystery.



Figure 1: Alan Turing in his younger years

In his vest pocket is a letter from the court. In a year, he'll face trial for "gross indecency" – a euphemism for homosexuality in repressive Victorian society. The irony of fate: a man who helped save

millions of lives will be persecuted for whom he loves. Perhaps this very experience with how society defines “normality” and “humanity” leads him to a deeper question: What actually makes a human human? Is it biology, or something else?

He takes his pen and writes the first sentence of an article that will change history: “I propose to consider the question: Can machines think?”

This question wasn’t the first of its kind. Humanity has been asking similar questions for millennia, just in different forms. In ancient Greece, they told stories of Hephaestus, the divine blacksmith and god of fire, who created golden servants – automatons so perfect they could think and speak independently. These mythical beings foreshadow today’s questions about artificial intelligence: Can a machine truly understand, or does it merely mimic understanding?

Talos, the giant bronze guardian of Crete, circled the island three times daily, protecting it from intruders. He was a robot long before the word robot was invented – a machine programmed to fulfill its task with unwavering persistence. His story illustrates the age-old problem of autonomous systems: how to ensure they act according to our intentions while adapting to unexpected situations?



Figure 2: Talos on an ancient Greek vase (TONIO DELBARRIO6464, CC BY-SA 4.0, via Wikimedia Commons)

Pygmalion, the legendary sculptor, fell so deeply in love with his own statue Galatea that the gods heard his passion and brought the marble beauty to life. Isn't this a metaphor for every creator's desire – to breathe life into their work? This legend resonates with the modern debate about machine consciousness: at what point does simulation

become reality? When a machine perfectly mimics human reactions, is there still any difference between it and a human?

Medieval alchemists sought the recipe for a homunculus – an artificial being created in a flask. Jewish mysticism spoke of the golem, a clay servant animated by kabbalistic formulas. According to legend, Rabbi Loew in Prague created such a golem to protect the Jewish quarter from pogroms. When the golem became too powerful and uncontrollable, the rabbi had to remove the magic letter from its forehead and return it to dust. The golem's story is a warning that resonates today in discussions about AI safety: how do you shut down a system that escapes control?



Figure 3: Prague Golem

The Prague Golem – reproduction of the legendary figure from Jewish mysticism

These myths carry universal themes that resonate today: the desire to create artificial life, fear of losing control over one's creation, and the ethical dilemma of playing god. These are the same questions we ask today, only instead of magic and divine intervention, we have algorithms and computational power.

In the 18th century, myths began giving way to mechanics. Jacques de Vaucanson constructed a mechanical duck that could eat, digest, and excrete. It was an illusion – an ingenious fraud with hidden compartments – but the audience was fascinated. Vaucanson's duck reportedly had over 1000 moving parts, each feather carved individually. This obsession with detail foreshadows today's effort to create a perfect simulation of life through computational power.

Wolfgang von Kempelen built "The Turk," a chess-playing automaton that defeated even experienced players. Though a human was hidden inside, the idea of a chess-playing machine ignited generations' imagination. It's fascinating that The Turk inspired the term "Turing test" – Turing knew about this fraud, yet (or perhaps because of it) proposed a test where deception is a legitimate part of the game. If a machine can convincingly deceive that it's human, isn't that a form of intelligence?

Turing knew these stories. He also knew his generation had something previous ones didn't – the universal computing machine. In his 1936 work, he proved that an abstract machine exists capable of performing any computation that can be algorithmically described. Now he asks: Is thinking just a very complex computation? And if so, can a machine replicate it?

The history of automatons goes much further back than Vaucanson. Hero of Alexandria in ancient times constructed complex

mechanisms – automatic opening of temple doors using steam, mechanical theater with moving figures. His writings describe dozens of inventions that seemed miraculous but were based on simple physical principles.

In the Islamic Golden Age, scholar Al-Jazari created the “Book of Knowledge of Ingenious Mechanical Devices” (1206), describing dozens of automatons including a programmable musical automaton – a band of four musicians on a boat. Using pegs on a rotating cylinder, he could “program” different melodies. It was essentially a mechanical precursor to modern sequential programming. Even more important was the contribution of Al-Khwarizmi (780-850), the Persian mathematician whose name gave rise to the word “algorithm.” His book not only gave the world algebra but introduced systematic procedures for solving mathematical problems – the first algorithms in the modern sense.

The Renaissance brought a new wave of fascination with automatons. Leonardo da Vinci designed a mechanical knight capable of sitting, standing, moving its arms, and opening its helmet visor. While it’s unclear if it was ever built, the designs show sophisticated understanding of mechanics.

But back to Turing’s test. Its genius lies in bypassing the unsolvable question “what is thinking” and replacing it with a practical test: If you can’t distinguish a machine from a human in conversation, you must grant it some form of intelligence. It’s a pragmatic approach that opens fascinating philosophical questions.

René Descartes in the 17th century claimed that animals were mere automatons – complex machines without souls. According to him, only humans possess *res cogitans*, the thinking substance. Interestingly, Descartes believed no machine would ever be able to use language creatively and flexibly like a human. Turing’s test builds

precisely on this ability – using language as proof of intelligence.

The Japanese tradition has a different relationship with automatons than the West. *Karakuri ningyō*, mechanical dolls from the Edo period, weren't seen as fraud or life replacement, but as artwork worthy of admiration. The most famous is the “tea server” – a doll that brings a cup, waits for the guest to finish, and returns with the empty cup. This cultural difference might explain why Japan so readily accepted robots in modern times.

But back to Turing. His test has its critics. John Searle later introduced the “Chinese room” – a thought experiment questioning whether the ability to answer questions means true understanding. Imagine a person in a room who, using a huge book of rules, responds to Chinese characters without knowing Chinese. From the outside, it appears they understand Chinese, but in reality, they're just mechanically following rules. Searle's argument attacks the very core of Turing's test: if intelligence consists only of producing correct answers, then even a mechanical process can be “intelligent.” But it lacks consciousness, intent, true understanding – qualia, the subjective experience we can't yet define, let alone measure.

Outside it's still raining. Turing puts down his pen and lights a cigarette. Through the window, he sees students hurrying to lectures, covering their heads with newspapers. They live in a world where computers fill entire rooms and can barely add a few numbers. ENIAC, completed four years ago, weighs 30 tons and occupies 167 square meters. It consumes as much electricity as a small town. It's programmed by reconnecting cables and flipping switches.

But Turing sees further. He sees a future where machines won't just calculate but will be able to learn, adapt, perhaps even create. In his article, he writes about machines that would learn like children, gradually building their knowledge through interactions with the world.

This vision of a “child machine” was decades ahead of its time.

Perhaps the most remarkable thing about Turing's vision is its modesty. He doesn't predict conscious or sentient machines. He merely claims that machines can be intelligent in the sense that their behavior won't be distinguishable from human behavior. It's a scientifically sober approach that opens doors to endless possibilities.

When Turing completes his article “Computing Machinery and Intelligence,” which will appear in the journal *Mind*, he launches a debate that continues today. His question “Can machines think?” becomes the central theme of a new field – artificial intelligence. But that's a story just beginning...

Continuation: While Turing in Manchester lays the foundations of modern computer science, let's go back three centuries to a German polymath who first dreamed of a universal language of thought. Gottfried Wilhelm Leibniz believed that all truths could be expressed mathematically...

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2. Leibniz's Universal Language

Hanover, 1674. In a candlelit study, Gottfried Wilhelm Leibniz sits hunched over scattered papers. He is twenty-eight years old and his mind is possessed by a grand vision: to create a language in which every truth could be proven by mere calculation. “*Calculemus!*” – “Let us calculate!” – he has written in the margin of one paper. Whenever a dispute arose, one would simply sit down at a calculating machine and solve it like a mathematical problem.



Figure 4: Gottfried Wilhelm Leibniz - German polymath and visionary of a universal language of thought (circa 1700)

Leibniz was no mere dreamer. In his coat pocket lies a key to the adjoining room, where stands his latest invention – the Stepped Reckoner. It is a massive machine of polished brass, full of gears and shafts. Unlike Pascal’s calculator from 1642 – the Pascaline, an ingenious machine that could only add and subtract through a system of gears and ratchets – Leibniz’s machine could multiply and divide. Pascal created his machine to help his father with tax calculations; Leibniz had grander ambitions. When you turn the crank of his Stepped Reckoner, the gears mesh precisely and mechanically

perform the calculation. It is a marvel of precision engineering.

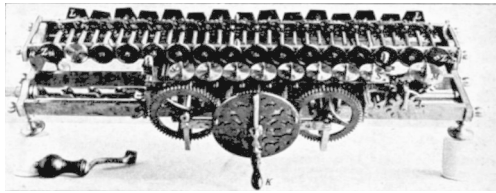


Figure 5: Leibniz's Stepped Reckoner – the mechanism of Leibniz's stepped calculator, a pioneering calculator capable of multiplication and division (1904, Wilhelm Franz Meyer)

But Leibniz's ambition reached far beyond calculating numbers. He dreams of a "*characteristica universalis*" – a universal language of thought, where every concept would have its unique designation, its number. Just as alchemists sought the basic elements of matter, Leibniz seeks the basic elements of thinking. He believes human knowledge can be broken down into elementary concepts and then combined according to precise rules.

"Imagine," he writes to his friend, "that we could express all thoughts as precisely as arithmetic. Disputes about God, about justice, about truth could be solved by calculation. Lawyers would become mathematicians of the mind!"

His contemporaries thought him mad. How could a machine capture the subtlety of the human mind? How could poetry be converted to numbers? But Leibniz had a concrete example of how his system would work. "Take the statement 'Socrates is a man,'" he explained enthusiastically to Duke Johann Friedrich. "In my system, 'Socrates' might be the number 13, 'man' the number 24, and the relation 'is' would be a mathematical operation. The statement 'All men are mortal' would be $24 \rightarrow 17$, where 17 is 'mortal.' The syllogism would then be mere calculation: if $13 \in 24$ and $24 \rightarrow 17$, then $13 \rightarrow 17$."

Leibniz saw deeper than his critics. He noticed that in Chinese writing, one character could express an entire concept. He studied Jesuit missionaries' writings about Chinese culture with fascination. He also studied Kabbalah, where Jewish mystics assigned numerical values to letters and sought hidden meanings through gematria. He intuitively understood that information could be encoded and manipulated symbolically.

In 1679, Leibniz began intensive work on a system that was three centuries ahead of its time. Studying the Chinese Book of Changes (I Ching), he noticed the system of lines – solid and broken – that the Chinese used to represent all aspects of reality. He was fascinated by the elegance with which just two values could express the entire universe. Inspired by this binary principle, he developed his arithmetic using only two digits: 0 and 1. He would not formally publish “*Explication de l'Arithmétique Binaire*” until 1703.

His binary system was not merely a mathematical curiosity. Leibniz saw in it a fundamental principle of reality. Everything could be expressed as presence or absence, yes or no, true or false. In his philosophy, he saw one as the symbol of God who created the universe from nothing – from zero.

“*Ex nihilo omnia*” – “Everything from nothing” – he wrote enthusiastically. Ones and zeros, being and non-being, true and false. In this simple system he saw a reflection of divine creation: God (1) created the world from nothing (0). He had no idea that his binary system would become the language of all computers three centuries later.

Leibniz's Stepped Reckoner was a technical marvel of its time, but also a symbol of his frustration. The machine could work with numbers up to 16 digits in multiplication and perform complex calculations far beyond Pascal's calculator. It used an ingenious system of stepped cylinders – each cylinder had teeth of different lengths, al-

lowing the transfer of different values. When a Parisian mechanic finally completed the machine, Leibniz proudly demonstrated it to the Royal Society in London.

Unfortunately, the machine never worked reliably. The technology of the time could not produce gears with the necessary precision. Every calculation required fine-tuning; sometimes the gears would jam. Leibniz spent a fortune on improvements, but imperfections persisted. "It is like human reason," he noted bitterly. "The principle is clear, but the execution is full of errors."

Yet his vision transcended technical limits. Leibniz realized it didn't matter whether the calculation was performed by gears, levers, or something else. What mattered was the principle: that symbols could be manipulated according to formal rules to arrive at new truths. This idea was so radical that it wasn't fully appreciated until the 20th century.

Among Leibniz's papers were found sketches of an even more ambitious machine – the *machina combinatoria*, which could automatically generate all possible combinations of concepts and thus discover new truths. It was a dream of mechanical creativity, of a machine capable of invention. Though he never built it, the idea of combinatorial exploration became the foundation of many later approaches to AI.

Leibniz's influence on later thinkers was enormous, though not always direct. When George Boole created his algebra of logic in the 19th century, he was directly building on Leibniz's vision of formalizing thought. Boolean algebra finally provided the mathematical apparatus for Leibniz's characteristic – though in a more limited form than Leibniz had dreamed.

Charles Babbage, when studying Leibniz's writings, was fascinated not only by the stepped calculator but especially by the idea of a uni-

versal computing machine. In Leibniz's notes he found sketches for "living accounting paper" – a machine that would remember intermediate results and use them in further calculations. This idea became the basis of Babbage's concept of the "Store" in the Analytical Engine.

But perhaps Leibniz's most important contribution was philosophical. His claim that all thinking could be reduced to combinations of simple elements foreshadowed modern computational theory. Alan Turing, when formulating his model of a universal computing machine, essentially realized Leibniz's dream – only instead of gears, he used abstract symbols on an infinite tape.

It's fascinating that Leibniz even anticipated the ethical problems of AI. In one letter he warned: "If machines can prove any truth, what will become of human wisdom? Won't we lose the ability for intuition and insight?" This concern resonates today in debates about whether AI will replace human thinking.

Leibniz's dispute with Newton over the authorship of calculus sheds interesting light on his character. While Newton developed calculus to solve physical problems, Leibniz saw it as part of a larger vision – a universal language for all sciences. His notation (dx/dy) proved more intuitive than Newton's and we use it today. It's a reminder that in the history of technology, the winner is often not who comes up with the idea first, but who expresses it best.

Leibniz's correspondence reveals fascinating details of his thinking. In a letter to Princess Sophie Charlotte he explains: "Imagine a library containing all possible books. Most would be nonsense, but somewhere among them would be all the truths of the universe. My universal language would allow us to systematically browse this space of possibilities and separate sense from nonsense."

This idea of a "library of all possible books" preceded Borges's "Li-

brary of Babel” by three centuries. But Leibniz went further – he believed it was possible to create an algorithm for efficiently searching this space. Today we would say he intuitively understood the problem of combinatorial explosion and was looking for a way to tame it.

His final years were marked by disappointment. Political intrigues stripped him of influence at court, his mathematical discoveries were overshadowed by Newton, and the Stepped Reckoner remained unfinished. Decades of work refining his ideas brought progress, but also awareness of how difficult his task was. Yet he never stopped working on his vision. Until his death in 1716, he wrote about the project of “scientia generalis” – a universal science based on calculation.

In the Hanover study, the candles are burning low. Leibniz rises from his desk, stretching his stiff back. Dawn is breaking outside. He has spent all night writing about his vision of a universal language. He records one last thought: “Perhaps the greatest obstacle is not technology, but human unwillingness to submit judgment to calculation. People want to be right, not to discover truth.”

He doesn't yet know that his dream of “calculemus” will one day become reality – just in a form he couldn't imagine. Instead of philosophical disputes, machines will calculate rocket trajectories, predict weather, diagnose diseases. And one day, more than three hundred years later, a machine using his binary system will write: “Leibniz was both right and wrong. Thinking can be partially formalized, but human intuition remains irreplaceable.”

Continuation: A century and a half later, in industrial England, another visionary dreams of a mechanical brain. Charles Babbage stands before a parliamentary committee, explaining why he needs more money for his peculiar invention. “Gentlemen,” he

says irritably, “imagine a machine that never makes an error in calculation...”

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3. Babbage’s Mechanical Brain

London, June 11, 1822. The meeting room of the Royal Astronomical Society is stifling. Charles Babbage, a thirty-year-old mathematician with wild curls and burning eyes, stands before an assembly of Britain’s most distinguished scientists. In his hand he holds a model of a machine that looks like a torture device made of brass and steel. “Gentlemen,” he begins, “I present to you a machine that will never make an error.”



Figure 6: Charles Babbage – mathematician and inventor of the mechanical computer (1791-1871)

A murmur ripples through the room. Sir Humphry Davy, President of the Royal Society, leans forward. Babbage continues: “The astronomical tables upon which our navy’s navigation depends are riddled with errors. Humans calculate them, humans copy them, humans print them. And humans err. My Difference Engine will calculate automatically, mechanically, infallibly.”

The story began several years earlier with a seemingly ordinary scene. Babbage sat with his friend John Herschel in a Cambridge

college, checking astronomical tables. These were tedious but vital books filled with numbers – planetary positions, eclipse times, navigational data for ships. Each page contained hundreds of calculations, each calculation could contain a fatal error.

“Look at this,” Babbage said, pointing to a line. “Here’s an error. And another here. And here...” Herschel sighed. As the son of the famous astronomer William Herschel, he knew well how these errors endangered ships on the oceans. Erroneous tables had once led a French captain to the Caribbean instead of the Gulf of Mexico.

“I wish to God these calculations were executed by steam!” Babbage exclaimed desperately, throwing his pencil on the table. Herschel laughed, but Babbage was already seeing something else – gears in motion, mechanical processes replacing human errors.

Babbage’s vision gradually crystallized. He began to imagine a machine that wouldn’t just calculate, but calculate without the possibility of error. A machine that would replace tired human brains in endless computations. His Difference Engine wasn’t just a bigger calculator. It was the first attempt to automate intellectual work, to mechanize thinking itself. The principle was elegant: the machine would calculate polynomial functions using the method of finite differences – a mathematical trick discovered in the 17th century that converts complex calculations into repeated addition. Squares, cubes, logarithms – everything could be reduced to simple arithmetic operations.

Imagine a table of logarithms. Instead of a human calculating it for months, risking error at every step, Babbage’s machine would produce it in days mechanically, without a single mistake. But the most revolutionary aspect was something else: the results would be printed directly onto metal plates, which would then serve as printing matrices. It would literally be a “book without human hands” –

from calculation through typesetting to printing, humans wouldn't touch the data once.

The British government, dependent on precise navigation for its empire, provided Babbage with an incredible £17,000 – more than the cost of two warships, approximately 340 annual wages of a skilled worker. Babbage rented workshops, hired the best mechanics, ordered special tools. But the more he thought about the machine, the more ambitious his vision became.

In 1834, in the midst of building the Difference Engine, Babbage experiences a moment of genius. He stands in a Lyon factory before a Jacquard loom – a machine fascinating all of Europe. Punched cards guide needles with incredible precision. Jacquard's 1801 invention revolutionized the textile industry – cardboard cards with an elaborate system of holes controlled the movement of thousands of threads. Each hole tells the machine: "Lift this specific thread here." Each unpunched spot: "Leave the thread down here." From combinations of thousands of such simple decisions emerge the most complex patterns – flowers, birds, entire scenes. It's a program, instructions encoded in matter.

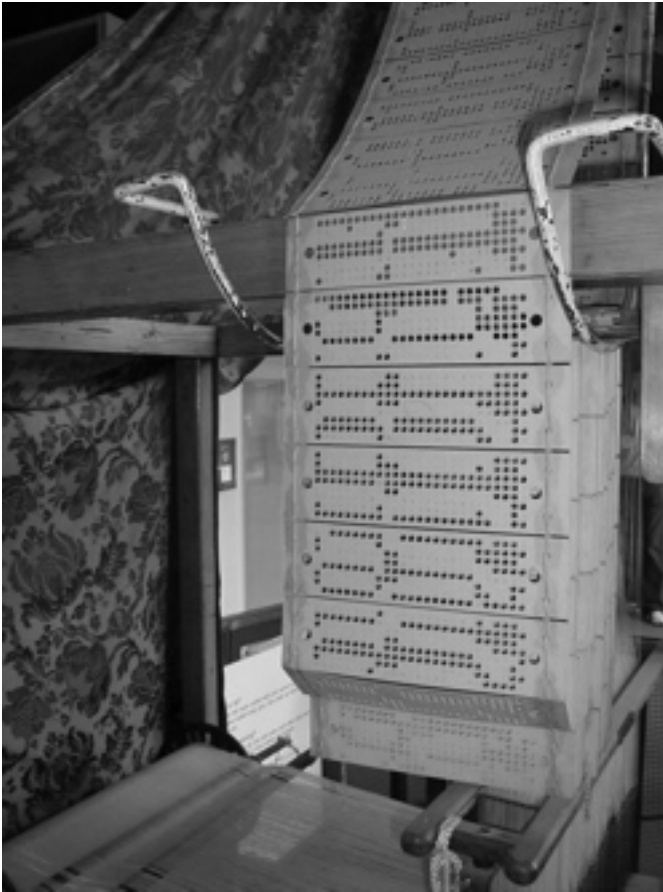


Figure 7: Jacquard loom – revolutionary programmable mechanism for weaving patterns with punched cards

Babbage watches the cards roll over the machine. A rose pattern is born without human intervention, just according to instructions encoded in holes. And then enlightenment strikes: What if he could program his calculating machine this way? What if he could change sequences of operations, what if one machine could perform any calculation, not just the one it was built for?

“Good God,” he whispers, “I’ve invented a universal machine!”

Thus the Analytical Engine is born – the first design for a universal computer. It would have a “mill” (processing unit), a “store” (memory), input via punched cards, and output to a printer. It even includes conditional branching – the machine can change its behavior based on intermediate results. It’s a computer designed a hundred years before its time.

Babbage becomes obsessed with his vision. He cancels social obligations, neglects his professorial duties at Cambridge, spends his entire fortune. His house on Dorset Street transforms into a mechanical inferno full of models, drawings, and experiments. Charles Dickens describes a visit: “Tables covered with countless drawings, models of machine parts, gears and levers everywhere. Mr. Babbage enthusiastically explained how his machine could calculate Bernoulli numbers, solve simultaneous equations, even play chess. It was like looking into the future.”

The Analytical Engine was to be a technical marvel: 25,000 mechanical parts, weighing several tons, three meters tall. The “Mill” would perform arithmetic operations – addition in 3 seconds, multiplication in a minute. The “Store” would hold up to 1,000 numbers, each with 40 digits – approximately 40 kilobytes of memory in today’s terms. Punched cards would contain instructions, other cards data. The machine could branch programs based on intermediate results, repeat operations, work with conditions.

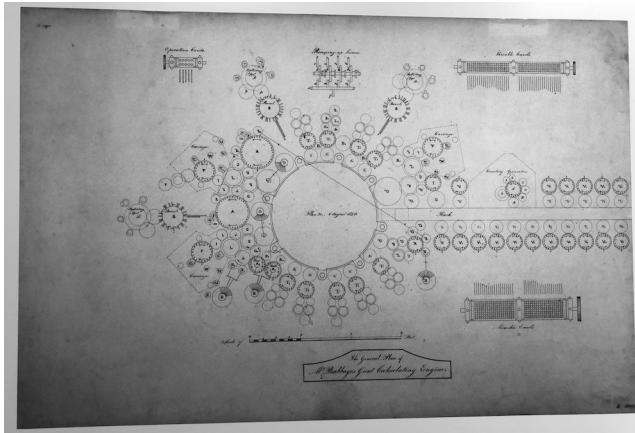


Figure 8: Analytical Engine plan – Babbage’s machine plan from 1840, first design of a universal mechanical computer (CC BY 4.0)

But the most brilliant aspect was something else: Babbage realized his machine could manipulate symbols, not just numbers. In one letter he writes: “The Analytical Engine can work with anything that can be expressed in symbols – with algebra, music, logical propositions, even with words.” It was the first glimpse of what we now call symbolic computation.

But the collision of reality with vision was cruel. Victorian technology, even the most advanced, couldn’t produce thousands of parts with the required precision. Tolerances had to be to thousandths of an inch – something unheard of for craftsmen of the time. Each gear had to be made by hand, filed, polished, tested. One small piece could take weeks of work.

Babbage constantly argued with mechanic Joseph Clement about costs and procedures. Clement was a genius in his field, but also a stubborn craftsman who didn’t want to be lectured by a theorist. When Babbage proposed design changes, Clement demanded to be paid again for all previous work. When Clement demanded better

tools, Babbage protested the costs. Their disputes dragged on for months.

The parliamentary committee gradually lost patience. The originally promised machine for £17,000 had become an endless computing project costing £23,000 (over 2 million pounds in today's money), with no end in sight. In 1842, the government definitively ended funding. Lord Derby said: "We have invested in air."

Babbage is broken but not defeated. He continues theoretical work until the end of his life, improving designs, experimenting with smaller models. In his final years, only his closest friends visit – Ada Lovelace, who understands his vision, and a few other scientists. Most of the scientific community considers him a genius who went mad.

"A time will come when these machines will be built and will have an immeasurable influence on mankind," he writes in one of his last letters. "Perhaps not in my lifetime, perhaps not in my children's lifetime, but it will come. And then people will understand that we weren't building mere calculators, but mechanical brains."

His prophetic insight into the future was fascinating. In one Analytical Engine design, he described how the machine could play chess: "The machine could keep in memory the positions of all pieces, evaluate every possible move, select the best according to established rules." He was essentially describing game AI a century before its emergence.

The tragedy of Babbage's life is that he was right, but too early. His Analytical Engine contained all the basic principles of a modern computer: separation of data and instructions (a principle later known as von Neumann architecture), conditional branching (if-then logic), loops, even hints of subroutines. Had it been built, the computing revolution might have come a century earlier.

Babbage's final years were marked by isolation. Victorian society saw him as an eccentric obsessed with mechanical toys. His parties, once centers of London's scientific society, were attended only by his most courageous friends. Babbage became a symbol of ambitious failure.

When he died in 1871 at age 79, the obituaries were lukewarm. The Times wrote: "Professor Babbage was undoubtedly a genius, but a genius incapable of completing his visions." No one suspected that in a hundred years his ideas would be the foundation of the world economy.

His son Henry attempted to complete at least part of the Difference Engine, but it was only an epilogue to a great drama. The mechanical parts were sold for scrap, the drawings ended up in archives. It seemed Babbage's dream died with him.

But Babbage ultimately won. Only in 1991, on the occasion of the bicentennial of his birth, did London's Science Museum finally build a working Difference Engine according to the original plans. Twelve years were spent manufacturing 8,000 parts with Victorian precision. The result? The machine works perfectly. Every calculation is correct to all 31 places.

It's a vindication of a genius who was ahead of his time. Babbage was right – the world just wasn't ready for mechanical brains.

Continuation: At one of Babbage's parties in 1833, a young woman with penetrating eyes appears. Ada Byron, future Countess of Lovelace, sees in the mechanical machine something that perhaps even Babbage himself doesn't see...

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